

Chapter 6

MONITORING

In the 1950s, W. Edwards Deming recommended that business processes be placed in a continuous feedback loop so the parts of the process that need improvement can be identified and changed (Arveson 1998). The individual Deming processes are defined as:

PLAN: Design or revise business process components to improve results;

DO: Implement the plan and measure its performance;

CHECK: Assess the measurements and report the results to decision makers; and

ACT: Decide on changes needed to improve the process (Arveson 1998).

A simple figure created by Deming illustrates the continuous process referred to as the PDCA cycle as shown in Figure 6.1.

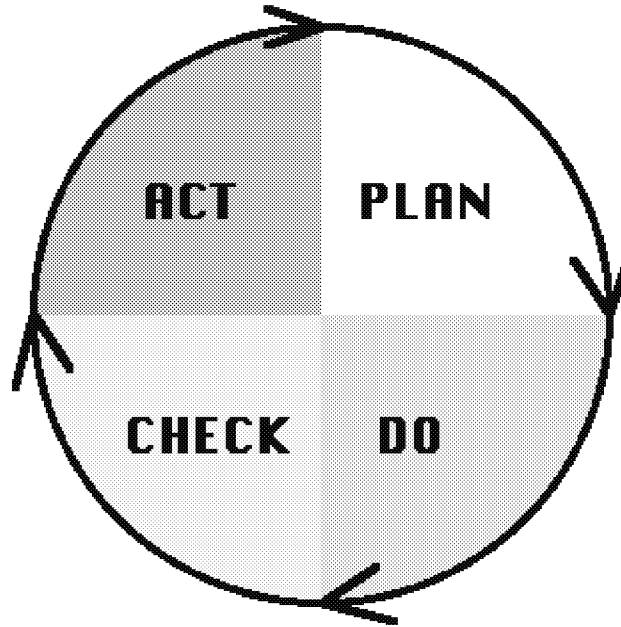


Figure 6.1 – Deming’s PDCA cycle of continuous improvement (Arveson 1998).

6.1 Current Assessment and Monitoring within the CWPPRA Program

Monitoring compares actual performance to predicted performance (Herbich 2000). This comparison enables continual improvements as the PDCA cycle illustrates. The value in collecting post-construction data was recognized by the CWPPRA Task Force in 1992, hence a monitoring program was planned. Standardized monitoring protocols were developed based upon the type of CWPPRA project, with results being used to judge project success or failure (Steyer and Stewart 1992). Each completed CWPPRA project has an Operations, Maintenance and Monitoring Plan developed during engineering and design which identifies the operation and monitoring procedures and a tentative schedule of field visits. The monitoring protocols for shoreline protection projects usually consist of measuring the shoreline position over time. Measurements are then compared to

unprotected reference areas in order to evaluate the effectiveness of the shoreline protection feature.

It is important to understand how the LDNR Office of Coastal Restoration and Management is structured, and how the responsibilities and actions of the LDNR coastal divisions impact the likelihood of continual process improvement in CWPPRA project designs. The LDNR organizational chart is shown in Figure 6.2 with the Office of Coastal Restoration & Management highlighted by the red box.

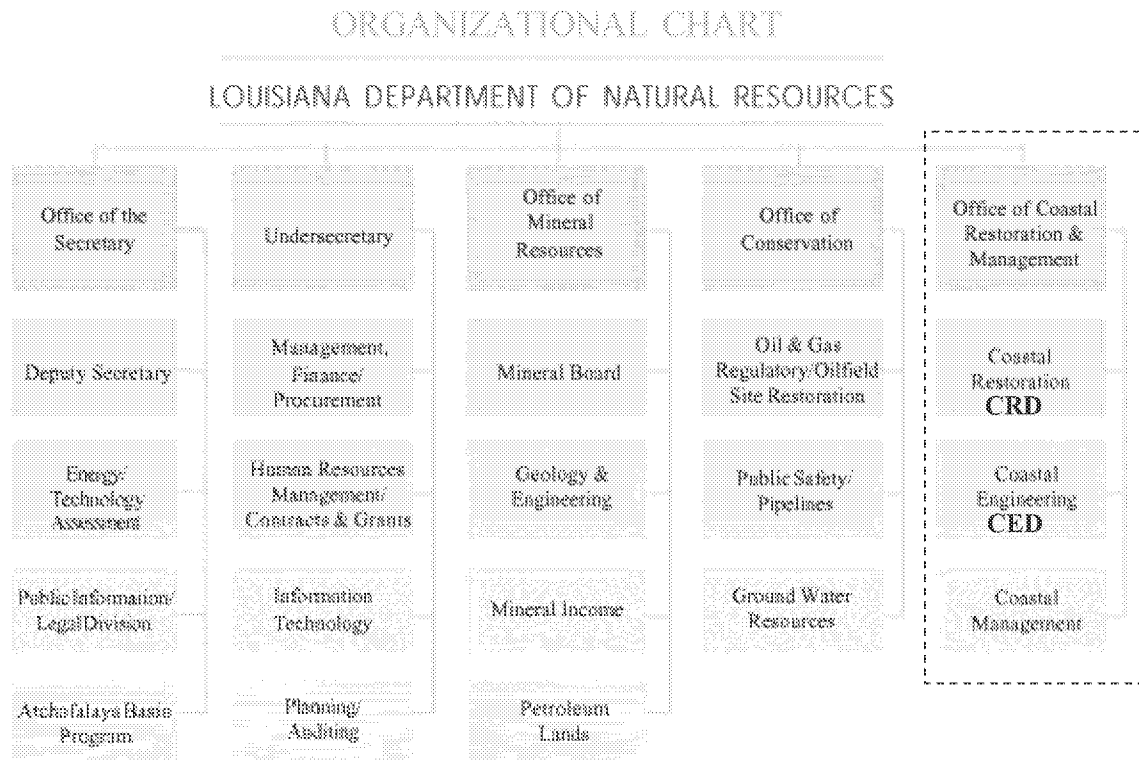


Figure 6.2 – Organizational chart for LDNR (emphasis added) (LDNR 2006).

In 1994, the Task Force decided that LDNR CRD would be responsible for the management of CWPPRA monitoring activities including monitoring plan development, data collection and storage, statistical analysis, quality control, data interpretation, and report generation (PPL 4 1994). LDNR's CRD was reorganized in 2003 and divided into Coastal Restoration (LDNR/CRD) and Coastal Engineering (LDNR/CED) (LDNR a 2006). The Biological Monitoring Section within LDNR/CRD collects ecological, hydrological, and climatological data as part of the overall effort to evaluate the effectiveness of CWPPRA projects (CRD 2003). LDNR/CRD site visits to the CWPPRA projects are usually conducted every three years as prescribed in the CWPPRA project's Operations, Monitoring and Maintenance plan.

The LDNR Coastal Engineering Division (LDNR/CED) consists of three sections and a coastal geologist as shown in Figure 6.3.

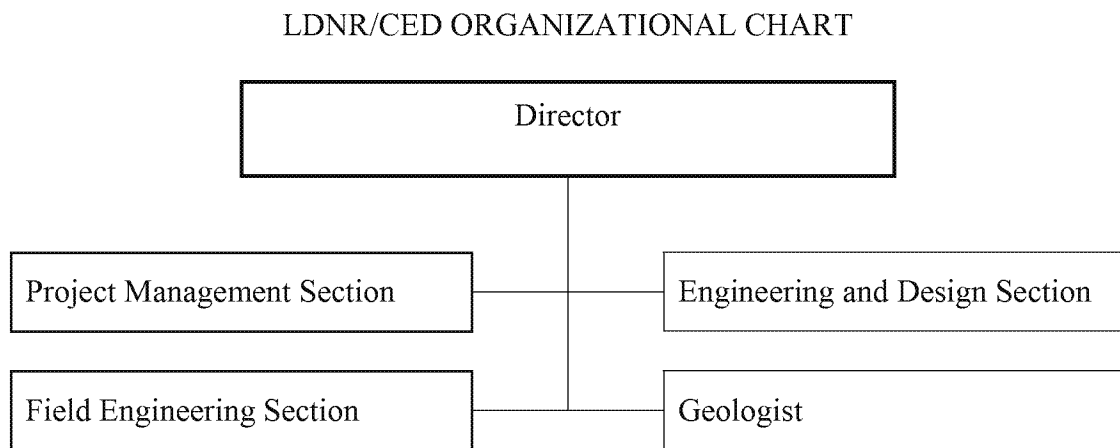


Figure 6.3 – LDNR/CED Organizational Chart (LDNR QAPP 2005)

Overall, LDNR/CED is responsible for designing and maintaining coastal restoration projects, however some of the CWPPRA federal agencies design their own projects with in-house engineering staff or by contract. The LDNR/CED Field Engineering Section is responsible for construction administration/inspection of LDNR construction contracts; and the operations/maintenance, and preparation of annual inspection reports for all completed CWPPRA projects (LDNR FES 2005). The staff is located in three offices in the cities of Thibodaux, Lafayette, and New Orleans. Field Engineering Section personnel conduct project inspections during construction, and are also responsible for post-construction follow-up including site visits to determine maintenance needs. LDNR/CED engineers from the Engineering and Design Section and project managers from the Project Management Section, all located in Baton Rouge, typically do not attend these field visits. Coordinating project design with field construction personnel is a proven procedure for continually improving designs and ensuring project constructability. The need exists within the CWPPRA program to continually share the lessons learned by the LDNR/CED Field Engineering Section not only with the LDNR/CED engineering staff and project managers, but also with the other CWPPRA federal agencies.

This potential data gap has been recognized by LDNR and efforts are underway within the LDNR organization to address it. Some of the LDNR actions include giving the LDNR/CED Field Engineering Section an opportunity to review and comment on draft plans and specifications, and to participate in the 30% and 95% design review conferences when LDNR is the design engineer. CWPPRA federal agencies designing projects with stone features (primarily NRCS and USACE) also internally coordinate

their 30% and 95% level project designs with their respective field personnel, who provide valuable insight regarding constructability. LDNR/CED Field Engineering Section personnel have also begun attending some of the three year site visits conducted by LDNR/CRD. These actions represent progress, however the need still exists for sharing post-construction lessons learned by the various federal agencies, and collecting project specific data to improve project designs, particularly for shoreline protection features using stone.

A review of some completed CWPPRA projects was performed in 2002 by six federal agencies, four universities, and the State of Louisiana. The intent of this effort, known as the CWPPRA Adaptive Management Review, was to evaluate constructed projects, learn from accomplishments and mistakes, and improve the projects (Raynie and Visser 2002). Although several recommendations were developed, the report concludes that most projects had not been completed and in service long enough to have sufficient data for conducting thorough reviews (Raynie and Visser 2002). Some of the recommendations in the December 2002 report have been implemented, but there are issues that remain unresolved.

In order to evaluate how the landscape is changing and understand the collective effectiveness of the CWPPRA projects, LDNR worked with USGS, University of Louisiana at Lafayette, and Louisiana State University to develop CRMS-Wetlands (CRMS 2004). The CRMS-Wetlands system consists of a network of reference sites across 3.67 million acres of coastal Louisiana wetlands (CRMS 2004). As of October 2005, 40 of the proposed total of 612 CRMS sites have been installed for monitoring

water level, salinity, sedimentation, elevation, and variety and abundance of vegetative species; and for gathering data regarding land-to-water ratios (CRMS 2004 and TC October 2005). Data collection was expected to begin in April 2006 (TC October 2005). The focus of CRMS-Wetlands is on ecological indicators and changes in landscape. Although this data is needed and worthy of the investment, CRMS will not provide the project specific data needed to assess the engineering performance of stone structures placed in coastal Louisiana, improve design efforts, and assist LDNR/CED in monitoring these structures for maintenance.

6.2 Proposed CWPPRA Process Improvements

A review of CWPPRA Standard Operating Procedures (SOP) reveals that the CWPPRA process is thorough in its planning and design review meetings and requirements, however procedures are lacking pertaining to post-construction follow-up. Many project managers recognize the need for proper project planning, however it is not uncommon for project termination planning or closeout to be neglected (Kerzner 2001). Project closeout procedures are discussed in CWPPRA SOP; however, the requirements are focused towards financial matters, which is only one part of project closeout. Confusion also exists over the definitions of the terms “construction complete” and “project complete”, each of which has financial implications with respect to project maintenance. Dr. Kerzner recommends establishing a simple project closeout procedure identifying major steps and responsibilities. Three easily implementable closeout procedures for the CWPPRA program include:

- requiring a post-construction/project completion meeting;
- archiving as-built documents; and,
- establishing a five-year post-construction project review.

Since the State of Louisiana is responsible for inspection and maintenance, there is the potential for information gaps developing between the federal entities that plan and design CWPPRA projects and the valuable lessons learned by the state during construction and monitoring throughout the design life of the project. One easy and initial process change to reduce the likelihood of this information disconnect is for the CWPPRA Task Force to implement a mandatory post-construction/project completion meeting, hosted by the project's federal sponsor and/or LDNR, to share lessons learned during construction with the other CWPPRA federal agencies. The NRCS already conducts internal post-construction meetings with NRCS planning and design engineers, field personnel, contractor and inspectors for their projects. This opportunity for sharing lessons learned and discussing recently completed CWPPRA projects with all of the CWPPRA federal partners and the State of Louisiana should be implemented as a requirement within the CWPPRA SOP. The SOP already mandates at least two required meetings during design, at the 30% and 95% completion levels. In addition to sharing valuable lessons learned, this post-construction project review would provide a formal mechanism to ensure project completion reports and as-built construction drawings are completed and submitted to the CWPPRA project archives.

Another needed improvement is ensuring the availability of as-built construction documents for completed CWPPRA projects. In accordance with standard engineering

practices and project management principles, project completion reports and as-built drawings are presently being accomplished for CWPPRA projects. The official CWPPRA project archives reside at the USACE, New Orleans District, and the District files do contain as-built documents. Unfortunately, a review conducted in July 2005 revealed that as-built information for less than 50% (35/72) of the completed CWPPRA projects could be found in the USACE CWPPRA project archives. Similarly, as-built documents for only 67% (48/72) of CWPPRA projects were found in LDNR CED project files in Baton Rouge. Although the USACE, New Orleans District, is the designated archive for CWPPRA documents, LDNR offices should have ready access to a complete set of as-built documents for all CWPPRA projects because the State of Louisiana is responsible for ongoing operation and maintenance. LDNR/CED files could also serve as a backup archive location should the New Orleans District office and its website become inaccessible as occurred in 2005 after Hurricane Katrina.

CWPPRA as-built documents that do exist are available in both paper and electronic formats. Some project information is available on letter sized paper, full size and ¼ size drawing sheets, and in various file formats electronically stored on compact discs. In some cases, the as-builts are included as part of a project completion report. Electronic media are cost effective and space-saving for storing and archiving data, however strict reliance on electronic media cause future compatibility issues as technology advances and various storage media become outdated or if electrical power is lost. A standardized format for archiving the as-built information should be determined.

A resource already exists that LDNR could leverage for electronically archiving project information and ensuring that all CWPPRA partners and other interested entities have access to the as-builts. LDNR has established an online source of oil and gas drilling/production, state mineral leases, and coastal data (SONRIS 2005). Strategic Online Natural Resources Information System, referred to as SONRIS, provides access to electronic document images as well as electronic maps. Some CWPPRA project documents and geotechnical information are already available on SONRIS and the LDNR website. As-built documents for all CWPPRA projects could be incorporated into the SONRIS database for easy access (Haywood 2006). If public access to the information raises security concerns, the files could be password protected and thereby limited to those with a need to know, primarily CWPPRA federal partners and LDNR.

As previously discussed, CWPPRA has implemented a very thorough project planning process with explicit and detailed procedures. Unfortunately, once projects enter the construction phase, attention is often diverted to planning and implementing additional projects rather than following through with post-construction activities. This is certainly not unique to the CWPPRA program. The EPA Superfund Program offers a good model to mimic. In order to ensure that remedial alternatives continue to perform as designed with the intended results, the Superfund program implemented a five year review procedure. This review process assesses the protectiveness of the remedy after implementation (EPA OERR 2001). It is recommended that a similar five year post-construction assessment of CWPPRA projects be implemented to examine and reassess project performance, review monitoring information, and prescribe future monitoring

efforts. Similar to the CWPPRA Adaptive Management Review, an interagency team led by LDNR and having representatives from each of the CWPPRA federal agencies and academia would review post-construction project information and monitoring data, including visiting the site. A written report would summarize and document the review team's findings and recommendations. LDNR would brief the CWPPRA Task Force with the results.

6.3 Project Specific Engineering Data

Coney Island, New York was one of the earliest beach nourishment projects in the U.S. accomplished in the early 1920's (Campbell and Benedet 2004). Many beach nourishment projects have been built since and lessons were learned. However, it was several years before detailed monitoring was routinely implemented as a project feature (Herbich 2000). Improvements in design resulted not only from a better understanding of the processes, but also from significant monitoring efforts (Dean et al. 2005, Herbich 2000). In 1981, an evaluation of structural shoreline protection systems was conducted by Moffatt and Nichol for the USACE (REMR 1992). A USACE technical publication summarizing the results of this study states that most shoreline protection structures fail physically due to inadequate design (REMR 1992). Poor design "often results from inadequate assessment of the environmental factors that are influencing the shoreline erosion" and overlooking necessary design details (REMR 1992). Detailed monitoring of CWPPRA shoreline protection projects using stone would provide the data needed to improve design and performance of the structures.

Previous efforts to assess the engineering performance of CWPPRA shoreline protection projects using stone were limited due to a lack of project specific data. Due to the high variability of soil conditions in coastal Louisiana, site specific information is needed to verify design parameters and, if possible, identify areas where stone features should not be used due to the limitation of soil engineering properties. In addition to providing valuable feedback, continual reassessment and long-term monitoring of projects are necessary. Since the function of a project changes with age, deterioration can be progressive over time, and problems can develop and occur at any time during the history of a structure (USACE 1995). Proper maintenance requires accurate information regarding a structure's current and future condition. The required data is somewhat dependent upon the type of project and the following recommendations are presented as a general guide for CWPPRA shoreline protection projects using stone features, although the basic methodology could be adapted for other types of CWPPRA projects. The engineering data needed for stone features can be obtained from three activities:

- surveys;
- aerial photography; and,
- annual field inspections.

6.3.1 Surveys

Due to the poor bearing capacity of coastal Louisiana soils, placement of stone usually results in immediate settlement of the structure. In order to evaluate design constraints and assumptions, often based upon limited pre-construction geotechnical investigations, the response to loading over time must be captured and compared to the settlement curves

assumed applicable for design. Without site specific information, only a qualitative analysis of project performance can be performed, limiting its usefulness for improving future designs. The need exists to collect project specific quantitative field data in order to document performance. By surveying the crown elevations of the stone structures and settlement plates over time, the actual settlement of the structure can be tracked.

Due to the wide variety of soil/sediment conditions in coastal Louisiana, the frequency of field surveys are highly site and project dependent (Burkholder 2006, Haynes 2006, Khalil 2006). In general, more frequent surveys are anticipated during the first year post-construction, followed by additional surveys in year two, with another five year survey for projects with stone features (Jurgensen 2005, Joffrion 2005). It is also important to capture the structure's performance at the end of the design life, at 20-years post-construction for CWPPRA projects (Haynes 2006). Data from this 20-year post-construction survey would allow comparison to design assumptions for consolidation settlement, making it one of the most important evaluations (Haynes 2006). Settlement curves developed during design of the project would indicate the surveying frequency (Burkholder 2006, Haynes 2006, Khalil 2006). Adjusting the timing of the surveys to correspond to settlement milestones projected in the original project design would also lessen the potential for errors introduced by interpolating between the projected and measured settlement (Haynes 2006). The design engineer and/or design team should develop the post-construction survey protocol to ensure the proper data is obtained at the right time intervals in order to evaluate the design and performance.

One of the settlement curves used in the recent design of the Lake Borgne Shoreline Protection Project (PO-30) is shown in Figure 6.4. According to the final design report, settlement of the stone features during the 20-year design life varies from seven to 23 inches (LDNR PO 30 2005).

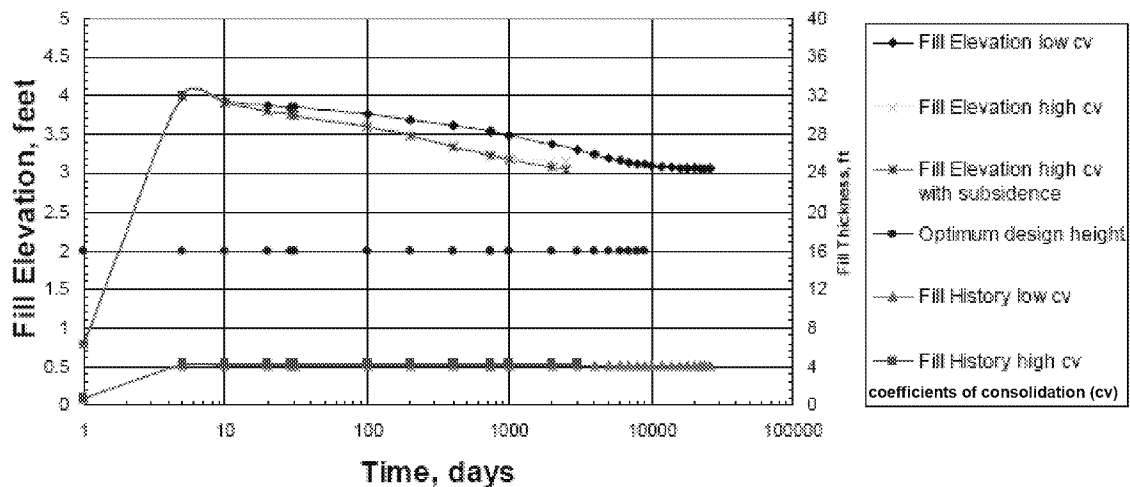


Figure 6.4 – Predicted settlement for Lake Borgne Shoreline Protection Project (PO-30) breakwater sections (LDNR PO-30 2005).

In the Lake Borgne Shoreline Protection Project, a minimum of seven survey events would be conducted in the first year post-construction to correlate with the predicted settlement. Additional events would occur at least at two years (700 days), 2.7 years (1,000 days), 5.5 years (2000 days), 8.2 years (3000 days), 11 years (4000 days), 13.7 years (5000 days), 16.4 years (6000 days), and 19.2 years (7000 days) post-construction during the 20-year CWPPRA design life.

Detailed analyses have been conducted for a few CWPPRA shoreline protection projects, namely in the Barataria Basin Landbridge area. The 2003 Annual Inspection Report for the Barataria Basin Landbridge Shoreline Protection Project (Phase I Construction Units 1 and 2) contains the results of settlement plate surveys performed by the NRCS. According to the report, over five ft. of settlement occurred at station 3+35 nine days after the settlement plate was initially surveyed, prior to rock placement (Babin 2003). In comparison, a little over one foot change in elevation occurred at station 6+10 after eight days (Babin 2003). Such variability in response confirms the need to develop a site specific and project specific surveying protocol.

In general, surveys would be aligned perpendicular to the centerline of the stone structures, extending approximately 100 ft. either side beyond the toe of the structure to capture the local environment's response to stone placement. Non-symmetrical structures may need surveys extending beyond 100 ft. for capturing additional bathymetry/topography information (Haynes 2006). Spacing of the survey transects would depend upon soil variability and the length of the structure. Ideally, monitoring surveys would correspond to original design cross sections and/or as built surveys for direct comparison. A transect should be located between every settlement plate location, typically every 1000 ft. All surveying work should be conducted under the direct supervision of a professional surveyor licensed in the State of Louisiana, and referenced to the Louisiana Coordinate System NAD 83 and NAVD 88. Elevations of settlement plate riser pipes should also be surveyed enabling comparison to elevations recorded by

the construction contractor prior to placing stone, and just prior to construction completion, final inspection, and project acceptance.

After the data is collected, it should be compared to design settlement curves. This requirement could be incorporated into the surveying contract or done in-house by LDNR. In addition to providing valuable feedback for the CWPPRA design engineers, comparing actual settlement to predicted and design values would assist the state in forecasting future maintenance events. The need for maintenance is project specific and based upon the rate of settlement and size of the rock (Burkholder 2006). Stone placed for CWPPRA projects varies by location, for example 250 lb class stone is typical in interior areas whereas larger stone (two tons) is often used in high energy, Gulf of Mexico exposures (Burkholder 2006). Advance knowledge of required maintenance of individual projects would facilitate combining maintenance events, and/or incorporating maintenance events with new construction, capturing economy of scale issues associated with stone construction. Maintenance of stone structures will become more critical as CWPPRA stone structures age, sea level rises, and additional CWPPRA projects are constructed since stone usage continues to increase within the program.

Survey transects would also detect possible scour conditions and document the sedimentation that is known to take place immediately behind nearshore rock breakwaters. It is currently unknown whether sediment accretion in the immediate vicinity of stone structures is material that used to be deposited onto the interior marsh surface before the stone was placed (Teague 2005). Extending transects beyond 100 ft. and into the existing marsh behind stone structures would provide additional data

regarding localized effects of structure placement and subsidence (Khalil 2006). Use of sediment elevation tables would also assist in evaluating interior marsh sediment accretion (Teague 2005). It is possible that placing stone structures to prevent erosion at discrete shoreline locations is counterproductive, further starving the interior marsh of sediment and inhibiting vertical accretion that could offset subsidence and rise in sea level.

On-the-ground surveys can be expensive and labor intensive. Airborne light detection and ranging (LiDAR) is a useful surveying tool that is faster and more cost-effective (Khalil and Lee 2004). LDNR plans to use LiDAR to monitor the coastal Louisiana barrier island system (BICM 2003). Unfortunately, LiDAR is not recommended for the stone project surveys due to its inability to provide information below the surface of turbid waters typical of coastal Louisiana, and concerns over the accuracy of the data needed. Ground surface elevations can also be screened out by vegetative cover.

Post-construction monitoring surveys could be accomplished in-house by LDNR, or by contract. Estimated contract costs for each survey event ranges from \$25,000 to \$50,000. Estimated costs are based upon the as-built survey line item submitted by the low bidder, and government cost estimates for the Chaland Headland Restoration project awarded in August 2005 (Williams 2005). Assuming a total of 17 surveying events adds an estimated \$425,000 to \$850,000 to the cost of a shoreline protection project. In some cases, this amount could represent as much as 10% of the initial cost of construction. The critical need for this data should offset concerns over short-term costs. The intent is to collect enough data to verify design coefficients/assumptions and establish patterns,

which will avoid wasting huge sums of money in the long-term for ill-advised stone placement projects. The need for intensive surveys could be re-evaluated after some data is collected, design assumptions verified, and overall benefits assessed. Funding for the monitoring should be incorporated into the long-term maintenance costs of CWPPRA projects currently under engineering design. The state can also request additional funds for maintenance of completed projects from the CWPPRA Task Force.

One way to reduce the costs of the surveys is to initially screen out certain project locations. Depending upon site specific conditions, areas having soils with suitable engineering properties and low erosion potential may not require intensive surveying. By using the NRCS listing of soil types in Louisiana and first hand knowledge of existing project performance, two site categories could be identified; stable and unstable (Broussard 2005). Shoreline protection projects proposed in potentially unstable areas would be surveyed to document their performance. Any questionable areas would be conservatively categorized as unstable. Another potential screening parameter would be high and low energy environments (Broussard 2005). Projects in high energy environments would also undergo intensive post-construction surveys. Examples of high energy locations include:

- exposure to the Gulf of Mexico;
- shorelines with large fetch distances, such as large lakes or bays; and,
- areas subjected to intense boat wakes from commercial marine vessels.

In addition to reducing the costs of monitoring, such screening information could be useful in determining whether placement of stone is appropriate.

6.3.2 Photography

Aerial photography is already used within the CWPPRA program to evaluate spatial changes in marsh coverage. For example, the NWRC in Lafayette documents land to water ratios. The NWRC uses 1:12,000 scale, near-vertical, color-infrared, aerial photography scanning the photos at 300 dots per inch and indexing and archiving the data (Thibodeaux 1998). Image processing and geographic information system (GIS) software is used to georectify the frames with ground control points collected in the field to create a photomosaic (Thibodeaux 1998). Using GIS analysis, land to water ratios are determined (Thibodeaux 1998).

Photography has also been used to document shoreline position, land/water areas, and shoreline change using shoreline markers for CWPPRA shoreline protection projects. High resolution aerial photography that is already being collected to measure shoreline retreat could be used to also monitor and measure performance of rock structures. Expanding use and frequency of aerial photography for shoreline protection projects would assist in evaluating performance of the structure, and evaluating marsh response well behind stone project features. Geo-referenced, project specific, near vertical aerial photographs at regular intervals, would assist project planners in identifying areas where placement of stone shoreline protection features may be inappropriate due to marsh subsidence induced by mechanisms other than shoreline erosion. It is recommended that aerial photographic surveys be completed at the following intervals:

- six months post-construction;
- two, five, ten, fifteen years post-construction; and,

- the end of the project design life (twenty years).

Aerial photographs could also be used to assess the overall settlement and performance of the rock structures themselves.

Aerial photography is the most useful method for monitoring changes in dune morphology (SNH 2000). LDNR used aerial photographs of the Timbalier Island Dune and Marsh Restoration (TE-40) project, completed in June 2005, to monitor project performance. A good example of this photography is shown in Figure 6.5 documenting pre-construction conditions, post-construction results, and effects of Hurricanes Katrina and Rita on Timbalier Island.

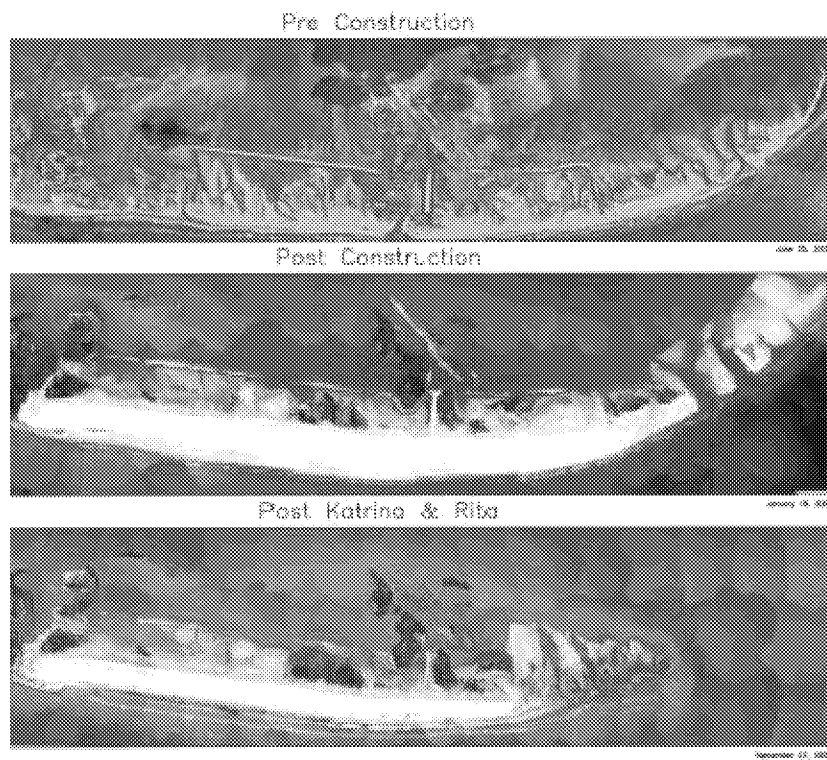


Figure 6.5 – Timbalier Dune and Marsh Restoration (TE-40) Project pre and post-construction, and post hurricane aerial photograph.

Cost of the georeferenced aerial photographs obtained by LDNR and shown in Figure 6.5, was approximately \$10,000 for each segment (Williams 2005). LDNR has drafted a Barrier Island Comprehensive Monitoring Program, which is designed to collect data for the entire barrier island system. Aerial photography is one component of the monitoring program (BICM 2003). Khalil and Lee also used this type of photography to assess performance of restoration projects for the Isles Dernieres (Khalil and Lee 2004). The proposed aerial photography events for stone features would add approximately \$60,000 to the cost of each project. Although cost effective, strict reliance upon aerial photography is not recommended, since aerial photographs taken at different times of year and variable water levels may impact interpretation and conclusions (Raynie and Visser 2002). The need exists to compare the photographs with actual field information (Broussard 2005).

6.3.3 Annual Inspections

Field inspections are used to evaluate the condition of structures, confirm they are operating correctly, and identify any deficiencies so appropriate maintenance can be performed. Due to the potential for rapidly changing conditions in coastal Louisiana, annual project site visits are also needed to document project performance. As mentioned previously, the LDNR/CED Field Engineering Section currently conducts annual site visits to determine maintenance requirements. The scope of the annual visit could easily be expanded for minimal additional cost to collect additional data and include the design engineer, LDNR project manager, and federal sponsor. These field visits would also provide a valuable training opportunity for new design engineering staff. After major

storm events, additional site visits would be required to verify the integrity of the structures. Post storm site visits were conducted by LDNR in 2005 after Hurricanes Katrina and Rita. The annual field inspection proposed for CWPPRA shoreline protection projects consists of three major tasks:

- preparation and pre-visit data gathering;
- actual field visit; and,
- post field visit follow-up actions.

Establishing a methodology, as shown in Figure 6.6, and a field visit checklist will help ensure that required data is collected in a consistent format, and that it is readily available for use. A prototype checklist is in Figures 6.7 and 6.8. Additional information could be attached to the form in a narrative format, if desired.

Site Visit Methodology

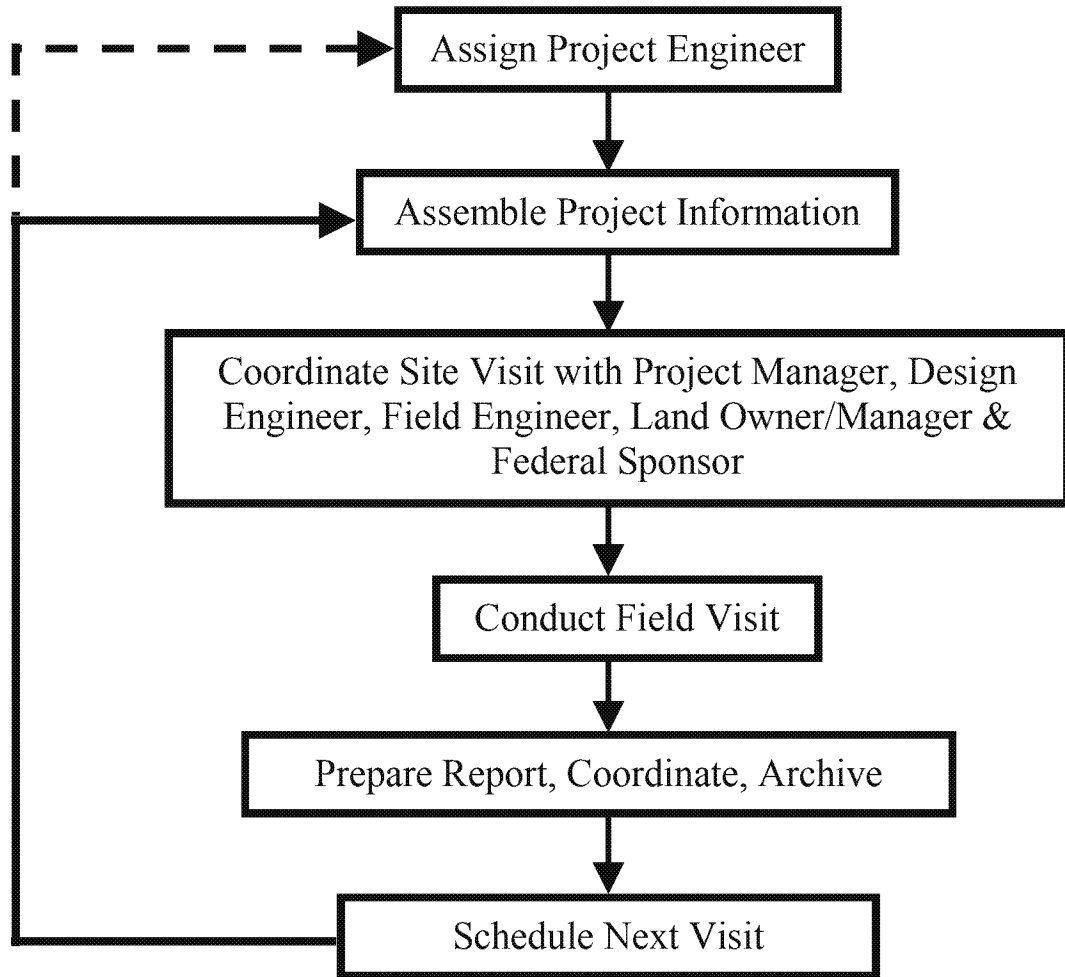


Figure 6.6 – Annual site visit methodology.

**Engineering Monitoring Plan for CWPPRA
Shoreline Protection Projects Using Stone
Field Observation Form**

Page 1 of ____

1.0 Background: Project Name: _____

Coast 2050 Region: _____ Federal Sponsor: _____

Project Location: _____ (parish) Construction completed: _____ (date)

Previous site visits: _____ (dates)

Constructed Features: _____

_____ Length (LF) of _____ # stone _____ tons placed

Crown height _____ Ft (NAVD 88) crown width _____ Ft side slopes _____ H _____ V

Source quarry: _____ Design specifics: geotextile (Y/N) geogrid (Y/N)
modified foundation (Y/N)

Settlement plates: _____ (quantity) spacing _____ (feet) warning signs _____ (quantity)

2.0 Field Observations: Date of Field visit: _____ Start Time: _____ End Time: _____

Weather: _____ Nearest Gage Height: _____

Attendees: _____

2.1 Structure: submergence, evidence of overwash and scour (Y/N) if yes, GPS location, photograph, and depth sound , note areas of sediment accretion and location(waterside or landside)

| Begin Station | End Station | Issue (submergence/scour/overwash/accretion [water or land]) |
|---------------|-------------|--|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

estimate percentage of total length submerged _____

maintenance needs: _____

general comments: _____

Figure 6.7 – Page 1 of prototype field checklist for annual site inspections.

2.2 General Field Condition/Integrity of Stone:

Page 2 of ____

Cracking (Y/N)

Deterioration (Y/N) loss of more than ¼ of original volume

Excessive movement (Y/N)

Cracking, deterioration, and excessive movement should be photographed and locations identified.

| Begin Station | End Station | Issue (submergence/scour/overwash/accretion [water or land]) |
|---------------|-------------|--|
| | | |
| | | |
| | | |
| | | |

maintenance needs: _____

general comments: _____

2.3 Settlement Plates and Warning signs: all accounted for? (Y/N) Photos taken? (Y/N)

| Settlement Plate Or Warning Sign | Original Elevation | Observed Elevation | Change in Elev. | Comments/Condition (missing/fair/good/excellent) |
|-------------------------------------|-----------------------|-----------------------|--------------------|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

3.0 Overall assessment of project performance: _____

Post Visit Comments/Recommendations/Lessons Learned: _____

Next field visit: _____ (month/year)

Field visit posted to tracking system by: _____ (date)

Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

Posted to _____ (shared drive) _____ (initials) _____ (date)

Copies provided to: QA Manager: _____ (date) Federal Sponsor: _____ (date)

Figure 6.8 – Page 2 of prototype field checklist for annual site inspections.

6.3.3.1 Preparation

Initial actions include assigning each project to an engineer responsible for the annual site visit. Continuity with the same project would facilitate data gathering but also increases the need for sharing lessons learned with other engineers/managers and requires standardizing data collection. Prior to the field visit, all existing data for the project should be gathered and reviewed. This information includes:

- design documents;
- post construction “as-built” drawings;
- construction specifications;
- project fact sheets;
- geotechnical data;
- local gage data;
- previous field visit memoranda for records;
- inspection reports;
- monitoring data; and
- photographs/videos.

The LDNR/CED Project Manager during project design and construction should be consulted for additional desk notes or photographs. The major landowner/land manager should also be contacted and advised of the need to access the property in order to evaluate the project conditions (Broussard 2006). Information is needed to complete Section 1.0 of the prototype Field Observation Form in Figure 6.7 in advance of the visit. It is important to be familiar with the project and design features prior to the field visit.

The visit should be arranged with adequate time for the federal agency sponsor, LDNR/CED Project Manager, construction engineer and/or design engineer to attend.

6.3.3.2 Field Observations

The purpose of the field visit is to examine the structure and associated features, noting any post-construction changes, assessing performance, and defining any needed maintenance. Safety is the utmost concern with any field operation. Since most of the CWPPRA shoreline type projects are located in remote areas and usually accessible only by boat, at least two employees should participate in the field visits. LDNR has already established safety plans and standard operating procedures for field visits. These procedures include requiring personnel to successfully complete boat safety classes, defensive driving courses, first aid, and communication protocols.

Rock structures may experience failure by three mechanisms: overtopping, instability, and/or internal seepage (USACE 1995). Initially, the overall integrity of the stone structure should be evaluated. A visual “windshield tour” of the entire length of the structure should be performed during the annual field visit noting any areas of differential settlement, scouring, and displacement of the stones and to determine if a maintenance lift is required. Areas of concern should be photographed and their locations identified by GPS equipment. By documenting these areas, it may be possible to correlate structures performance with geotechnical information obtained during the design phase to help improve future design efforts. Any submerged areas of stone should be noted, photographed, and an estimate made of the submerged length. If there is evidence of

overwash, it should be noted as well. Before or after the field inspection, local gage data should be examined to determine if water levels are higher or lower than expected.

Each settlement plate should be located and the elevation of the top of the pipe noted. The initial top of pipe elevations should be available from the as-built drawings or other auxiliary information provided by the construction contractor to the Contracting Officer or Contracting Officer Representative, during the construction phase. The pipe's vertical alignment in degrees should also be determined. The water level should be noted at the settlement plate locations and correlated to local tidal information for the day and time of the visit after returning to the office.

In addition to the overall structure, the appearance of the stone with respect to field durability should be noted. Any excessive cracking of the stones and/or deterioration greater than $\frac{1}{4}$ of the stone's original volume should be noted and the location identified.

Photographs should be taken of the settlement plates, rock structure, warning signs, special features such as fish dips or gaps for pipeline crossings, or any other items including locations of scouring or sediment accretion. The photographs serve to document performance, changed conditions, or areas of concern. With the advent of digital photography, the images can easily be stored electronically as an attachment to an electronic version of the field observation report.

6.3.3.3 Post Field Visit Activities

After the field visit, the point of contact should complete the report consisting of the completed field observation form and any attached narrative and send it to all attendees for review and comment. Upon resolution of any comments, the report should be

finalized, filed with the as-built and/or project file, and posted on a share drive for easy access by others. A copy of the report should also be made available to the LDNR/CED Engineering Quality Assurance Manager, LDNR/CED Project Manager, and the CWPPRA federal agency sponsor. If noteworthy observations and/or design recommendations are developed, the LDNR/CED Project Management and Engineering Sections should be specifically informed so design improvements can be immediately incorporated into projects currently under design, and into future projects. The next field visit should be identified on a master calendar.

6.4 Reducing the Costs of Engineering Monitoring:

As more CWPPRA projects are completed and older projects are near the end of their design lives, resources required to monitor projects will increase. Despite the value realized in collecting data on projects, the associated costs are often perceived as diverting funds away from additional project implementation. There are low cost methods to facilitate collecting valuable field information.

CWPPRA projects are often seen from the air or by boat during other field trips, although it is often difficult to identify them without GPS equipment and/or a thorough knowledge of the location of all of the individual projects. Regular photographs taken during project site visits can provide valuable monitoring and performance information when their location can be documented. Skyward facing aerial markers, as shown in Figure 6.9, are used by oil companies to denote pipelines during aerial inspections and maintenance. It is recommended that similar markers bearing the unique CWPPRA

project number be used to easily and inexpensively identify CWPPRA projects having stone features. The aluminum markers and the mounting frame are designed for immediate on-site assembly (RoDon 2005) and could be attached to settlement plate riser pipes. Laminated numbers are produced from an exterior grade ultraviolet resistant material and can be produced from a highly reflective material (RoDon 2005). Each aerial marker costs approximately \$150.00, has an expected life of 15-20 years and is designed to be visible from low flying aircraft at an altitude of 2,500 ft. (RoDon 2005). A prototype of the numbered markers and the dual mounting system are shown in Figure 6.9

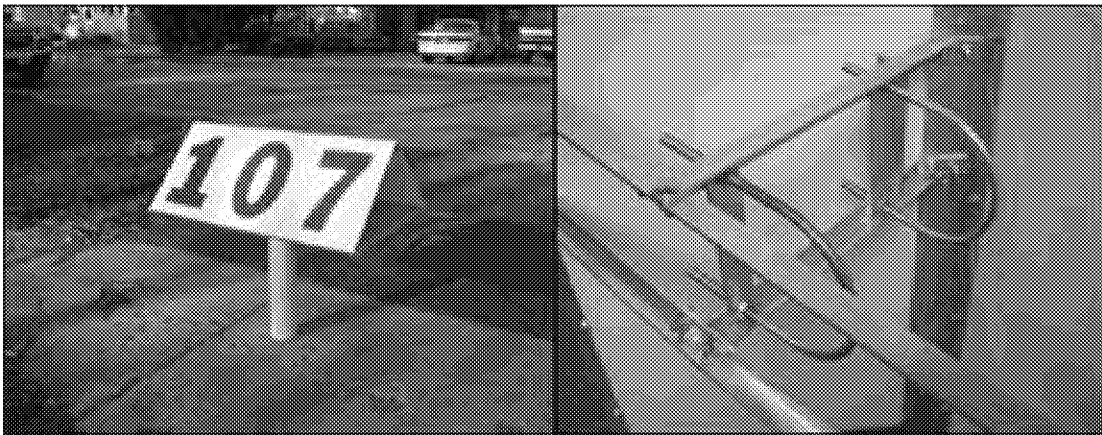


Figure 6.9 – Aerial pipeline observation marker and interior view of dual mounting system (RoDon 2005).

Telephone companies apply laminated markers to their outside cable plant pedestals. These one inch high letters are water resistant, highly visible, and extremely durable. The same approach is recommended for placing station numbers on the settlement plate

risers, facilitating field data gathering and documentation. Marking the station numbers on the settlement plate riser poles is an inexpensive way to readily locate sections of the rock dikes with settlement issues. An estimate from The Decal Factory indicates that 500 decals 3 1/2" X 9 3/8" on white vinyl, with one printed color (black), adhesive on back, squared corners would cost \$0.732 each plus a \$50.00 setup fee. Future construction contracts could include marking the station numbers most likely with no or little additional costs added to the construction contract. Retrofitting each CWPPRA stone feature would cost approximately \$500.00:

92 miles of rock (485,760 ft.) – settlement plates every 1,000 ft.

485.76 or 486 riser poles – use 500 riser poles

500 X \$0.732 = \$416 including the \$50 setup fee (Decal Factory 2005).

By implementing the aerial markers and labeling for riser poles, additional sources of field information collected by volunteers would become available. The National Weather Service has successfully relied upon thousands of volunteers to collect climate and weather data for many years in a program called the Cooperative Observer Network (NAS 1998). A similar program would encourage submission of photographs and or e-mail information regarding CWPPRA project features. A weblink on the LDNR website and/or lacoast.gov and SONRIS would facilitate submission of information from volunteers.

Low altitude flyover videos taken annually of CWPPRA PPL candidate projects could also be expanded to include all CWPPRA projects. Many of the PPL candidate projects are in the immediate vicinity of existing CWPPRA projects and the existing projects are

often included in the video. With the aerial marker system in place, the structures would be readily identified enabling another visual assessment of the project performance. Low altitude airplane flights are estimated to cost \$1,830 per day, and helicopters flights cost approximately \$4,000 per day (TC October 2005).

6.5 Conclusions and Recommendations

The need for continual process improvement and the value in reassessment and monitoring have been recognized by the Task Force, as demonstrated by the 2002 CWPPRA Adaptive Management Review and implementation of the CRMS-Wetlands system. Biological and ecological monitoring is currently conducted for individual CWPPRA projects, and landscape scale data will soon be available from the CRMS-Wetlands system. Although collection of these data is important for the coastal restoration decision makers, it does not provide the project specific information needed to improve the engineering design of shoreline protection projects using stone nor does it allow assessment of design related performance of CWPPRA projects. Additional project specific engineering monitoring, including surveys, aerial photography, and annual site visits, is recommended for immediate implementation by LDNR to improve the design and performance of shoreline protection projects with stone features. The engineering monitoring concept and proposed plan was developed in coordination with state and federal engineers involved with CWPPRA projects and peer reviewed. Estimated costs for collecting this data ranges from \$475,000 to \$900,000 per project, with surveying representing 90% of the total. Additional labor costs for staff to prepare

for, attend, and document the annual site visit is not included in this estimate. The recommended engineering monitoring program should collect enough data to verify design assumptions and improve the design and performance of future stone structures. As data are collected and analyzed, it may become possible to reduce the frequency of the surveys, further reducing the cost of engineering monitoring for future projects.

LDNR has structured its office of Coastal and Restoration Management in an effort to biologically monitor and maintain the CWPPRA projects. Additional efforts are still needed to overcome the organizational/logistical/geographical barriers to sharing information and lessons learned from the construction of CWPPRA projects. Integrating the LDNR/CED Field Engineering Section personnel with LDNR/CRD's three year site visits for gathering ecological information represents a starting point. In order to improve designs, it is recommended the scope of LDNR/CED's Field Engineering Section annual site visits be expanded beyond simply assessing maintenance requirements to include gathering data on structure performance. As the number of CWPPRA projects with stone features continues to grow and the projects age, managing inspection and maintenance will become more critical and costly. Simultaneously scheduling inspection and maintenance events of nearby projects is recommended to minimize costs by taking advantage of the economies of scale.

The CWPPRA SOP needs to expand the project closeout process beyond merely financial concerns. The federal agency sponsoring the project and/or LDNR should host a post-construction follow-up meeting involving all CWPPRA federal agencies for sharing lessons learned and formally transmitting the project completion report and as-

built surveys to the official CWPPRA archive. A long-term strategy of archiving as-built documents and project completion reports for CWPPRA projects is critically needed. Ideally, a single asset inventory database complete with CWPPRA project features, project construction costs, site visit information including photographs and field notes, geotechnical information, project design specifics, cultural resource information, and as-built drawings could be used to effectively manage project design and maintenance issues. Creating and maintaining such a database would be resource intensive and, thus, not likely to happen. However certain aspects, such as completing and maintaining an as-built record archive incorporating site visit information, are feasible. The official CWPPRA archive for as-built documents at the USACE, New Orleans District, is incomplete and efforts should be made to obtain all missing documents. LDNR offices should have ready access to the archive through the SONRIS system to facilitate their maintenance responsibilities. LDNR is working towards building a GIS. Some geotechnical information and post-construction project data are already available on SONRIS. An interagency, five-year post-construction field review should be conducted for CWPPRA projects and the review information presented to the CWPPRA Task Force. Low cost and easy to implement ideas such as marking CWPPRA stone features with aerial markers and labeling settlement riser pipes would facilitate field data collection efforts.

Additional monitoring efforts beyond CRMS-Wetlands and those proposed here may be needed for other types of CWPPRA projects in order to advance restoration planning efforts. For example, installing wave gages on the Gulf and bay sides of barrier islands

would verify and quantify the wave reduction and/or impacts of these projects.

Monitoring is expensive, but continuing to design and construct shoreline protection projects using stone without gathering project specific performance data and assessing interior marsh impacts does not lead to continual process improvement and is not indicative of a quality system approach. As data are collected and lessons learned are shared, the need for intensive engineering monitoring of structures to improve designs should decline. Perpetuating the status quo results in wasting funds on designing and constructing stone shoreline protection projects with unknown and undocumented performance. A significant quantity of stone in coastal Louisiana is left behind that must be managed.